DOCUMENT RESUME

ED 125 613 IR 003 700

AUTHOR Madonna, Louis A.
TITLE The Student Flow System.
PUB DATE 17 Jun 76
NOTE 13p.

EDRS PRICE MF-$0.83 HC-$1.67 Plus Postage.
DESCRIPTORS College Students; *Higher Education; *Mathematical Models; Matrices; Models; *Student Distribution; Student Enrollment; *Student Mobility; Systems Approach; Transfers; *Transfer Students
IDENTIFIERS Student Flow

ABSTRACT

Simple continuity is applied with graph theory to generate a student flow model with multiple inputs and outputs. A graph of all semesters or nodes is laid out along with an input block for transfers in and an output block for transfers out. Arcs are connected from the zero node to the graduation node and these are placed in a time-forward position, then transfer flow arcs are placed into and out of each node. The model is solved using matrix mathematics. A college can use this system to generate data about student transfers into and out of the institution over a period of years. (CH)

**********
* Documents acquired by ERIC include many informal unpublished *
* materials not available from other sources. ERIC makes every effort *
* to obtain the best copy available. Nevertheless, items of marginal *
* reproducibility are often encountered and this affects the quality *
* of the microfiche and hardcopy reproductions ERIC makes available *
* via the ERIC Document Reproduction Service (EDRS). EDRS is not *
* responsible for the quality of the original document. Reproductions *
* supplied by EDRS are the best that can be made from the original. *
**********

ED125613 :

# THE STUDENT FLOW SYSTEM

U.S. DEPARTMENT OF HEALTH,
EDUCATION & WELFARE
NATIONAL INSTITUTE OF
EDUCATION

THIS DOCUMENT HAS BEEN REPRODUCED EXACTLY AS RECEIVED FROM THE PERSON OR ORGANIZATION ORIGINATING IT. POINTS OF VIEW OR OPINIONS STATED DO NOT NECESSARILY REPRESENT OFFICIAL NATIONAL INSTITUTE OF EDUCATION POSITION OR POLICY

Date: June 17, 1976

Prepared by:
L. A. Madonna



IR 003 700

## NOMENCLATURE

S number of students moving from one semester to another/unit time. With ST subscript refers to student hold-up or storage.

Subscripts

| | |
|---|---|
| $T_y$ | number of students transferred out/unit time. |
| $T_x$ | number of students transferred in/unit time. |
| ST | the storage of students or the number of students held back/unit time. |
| 0,1,2,3,etc. | refers to semesters. |

Superscripts

| | |
|---|---|
| 1,2,3,etc. | refers to semesters. |
| S | refers to entire flow system. |
| i | refers to semester index. |


## Acknowledgment

The author wishes to thank Mr. B. Parker and Mr. Thomas James for the drawing of the graphs and Miss Nancy Milliron for the typing of the manuscript.

## Introduction

Little or no effort is put into the study of student flow systems at the small college level. However, it is possible to apply simple continuity along with graph theory to produce helpful academic system analysis techniques which may be utilized by the college to generate important data on a continuous basis. Most of the information shown here will be new and helpful to small liberal arts colleges. It is to be expected that large universities should be applying this approach (or similar approaches) rather routinely.

As will be noted most of the calculations can easily be done by hand by someone in the office of the dean once the model has been clearly explained. Widener College academic system analysis has been in existence for about five years with a relatively large store of historical data being produced by hand calculations.

## The General Concept

The principal concept inherent in the technique is to lay out a graph of all semesters or nodes (0, 1, 2, 3, etc. to 9) along with an input (transfer in) block and an output block (transfer out). Arcs are connected from node zero (high school) to node nine(graduation). These are all placed in a time forward position. Into and out of each node (except 0 and 9) transfer flow arcs are placed; this forms a graphical format as shown in Figure I. The transfer blocks can be analyzed with regard to "Centers" or "Colleges" which would be rows of the block; the columns refer to the semester (or node) in which the transfer was made. One might discuss the student flow system as being composed of a simple network with multiple inputs and outputs.

## Mathematical Aspects of Student Flow System

Figure 1 may be represented in another mode with inputs, outputs and storages shown. Note the [illegible] flow symbols:

$S_{01}$, $S_{12}$, $S_{23}$, $S_{34}$, etc. are inputs into nodes 1, 2, 3, 4, etc.

$S_{01}$, $S_{12}$, $S_{23}$, $S_{34}$, etc. are outputs from nodes 0, 1, 2, 3, etc.

$S_{TX}^{1}$, $S_{TX}^{2}$, $S_{TX}^{3}$, $S_{TX}^{4}$, etc. are student transfers into nodes 1, 2, 3, 4, etc.

$S_{TY}^{1}$, $S_{TY}^{2}$, $S_{TY}^{3}$, $S_{TY}^{4}$, etc. are student transfers out of nodes 1, 2, 3, etc.

## The Use of Continuity

The nodal balances (semester balances) or continuity balances are now written using the word equation below:

$$\left\{\begin{matrix}\text{Student Flow}\\ \text{Out of Node}\end{matrix}\right\} - \left\{\begin{matrix}\text{Student Flow}\\ \text{Into Node}\end{matrix}\right\} + \left\{\begin{matrix}\text{Storage}\\ \text{of}\\ \text{Students}\end{matrix}\right\} = 0$$

Let the superscripts be the node under analysis. Also, x as a subscript designates an input; y as an output.

## Semester Balances (5)

For semester one (node 1):

$$\overbrace{S_{12}^{1} + S_{TY}^{1}}^{\text{Flow out}} - \overbrace{S_{01}^{1} - S_{TX}^{1}}^{\text{Flow in}} + \overbrace{S_{ST}^{1}}^{\text{Storage}} = 0 \qquad (2)$$

Semester 2:

$$S_{23}^{2} + S_{TY}^{2} - S_{12}^{2} - S_{TX}^{2} + S_{ST}^{2} = 0 \qquad (3)$$

Semester 3:

$$S_{34}^{3} + S_{TY}^{3} - S_{23}^{3} - S_{TX}^{3} + S_{ST}^{3} = 0 \qquad (4)$$

Semester 8:

$$S_{89}^{8} + S_{TY}^{8} - S_{78}^{8} - S_{TX}^{8} + S_{ST}^{8} = 0 \qquad (5)$$

If the equations for all nodes are added then an overall balance results for the system.

Overall Balance

$$S_{89} + (S_{TY}^{1} + S_{TY}^{2} + S_{TY}^{3} - - - - S_{TY}^{8}) - S_{01} - (S_{TX}^{1} + S_{TX}^{2} + S_{TX}^{3} - - - - - S_{TX}^{8}) + S_{ST}^{s} = 0 \quad (6)$$

Generally the nodal balances can be shown as:

$$S^{i}_{i,(i+1)} - S^{i}_{(i-1),i} + (S_{TY} - S_{TX})^{i} + S_{ST}^{i} = 0 \quad (7)$$

i = the semester under analysis

Example: i = 1

$$S_{12}^{1} - S_{01}^{1} + (S_{TY} - T_{x})^{1} + S_{ST}^{1} = 0 \quad (8)$$

i = 2

$$S_{23}^{2} - S_{12}^{2} + (S_{TY} - S_{TX})^{2} + S_{ST}^{2} = 0 \quad (9)$$

Etc.

Expression (7) and (6) are in essence all that is needed to study a particular graduation class. For one interested in showing or using this approach in matrix form equations (2), (3), (4) etc. may be placed in matrix notation.

$$\begin{bmatrix} S_{12}^{1} \\ S_{23}^{2} \\ S_{34}^{3} \\ | \\ | \\ | \\ | \\ S_{89}^{8} \end{bmatrix} - \begin{bmatrix} S_{01}^{1} \\ S_{12}^{2} \\ S_{23}^{3} \\ | \\ | \\ | \\ | \\ S_{78}^{8} \end{bmatrix} + \begin{bmatrix} (S_{TY} - S_{TX})^{1} \\ (S_{TY} - S_{TX})^{2} \\ (S_{TY} - S_{TX})^{3} \\ | \\ | \\ | \\ | \\ (S_{TY} - S_{TX})^{8} \end{bmatrix} + \begin{bmatrix} S_{ST}^{1} \\ S_{ST}^{2} \\ S_{ST}^{3} \\ | \\ | \\ | \\ | \\ S_{ST}^{8} \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \\ 0 \\ | \\ | \\ | \\ | \\ 0 \end{bmatrix} \qquad (10)$$

or more compactly:

$$\overline{S}^{i}_{i,(i\div i)} - \overline{S}^{i}_{(i-1),i} + \overline{(S_{TY} - S_{TX})}^{i} + \overline{S}^{i}_{ST} = \overline{0} \qquad (11)$$

The bar over the symbol denotes matrix.

The application of this model to a case will now be shown.

Solution to Simple Problem

In equation (10) it is obvious that eight simultaneous equations exist. This then permits eight unknowns to be present in the model. A typical problem might be to calculate all of the inputs on transfers for a specific class. See Figure 2 for completed flow chart.

Given Data

Inputs:

$S_{01}^{1} = 100$

$S_{12}^{2} = 92$

$S_{23}^{3} = 86$

$S_{34}^{4} = 85$

$S_{45}^{5} = 78$

$S_{56}^{6} = 76$

$S_{67}^{7} = 75$

$S_{78}^{8} = 75$

Outputs:

$S_{12}^{1} = 92$

$S_{23}^{2} = 86$

$S_{34}^{3} = 85$

$S_{45}^{4} = 78$

$S_{56}^{6} = 76$

$S_{67}^{6} = 75$

$S_{78}^{7} = 75$

$S_{89}^{8} = 75$

Assume No Storage.

Therefore:

$S_{ST,}^{1}$, $S_{ST,}^{2}$ Etc = 0

Transfer Inputs:

$S_{TX}^{1} = 1$

$S_{TX}^{2} = 1$

$S_{TX}^{3} = 7$

$S_{TX}^{4} = 2$

$S_{TX}^{5} = 0$

$S_{TX}^{6} = 0$

$S_{TX}^{7} = 0$

$S_{TX}^{8} = 0$

Unknowns:

$S_{TY}^{1}$, $S_{TY}^{2}$, $S_{TY}^{3}$, $S_{TY}^{4}$, $S_{TY}^{5}$, $S_{TY}^{6}$, $S_{TY}^{7}$, $S_{TY}^{8}$

Putting the known values of the symbols shown in (10) into that equation gives:

$$\begin{bmatrix} 92 \\ 86 \\ 85 \\ 78 \\ 76 \\ 75 \\ 75 \\ 75 \end{bmatrix} - \begin{bmatrix} 100 \\ 92 \\ 86 \\ 85 \\ 78 \\ 76 \\ 75 \\ 75 \end{bmatrix} + \begin{bmatrix} (S_{TY}^{1} - 1) \\ (S_{TY}^{2} - 1) \\ (S_{TY}^{3} + 7) \\ (S_{TY}^{4} - 2) \\ (S_{TY}^{5} - 0) \\ (S_{TY}^{6} - 0) \\ (S_{TY}^{7} - 0) \\ (S_{TY}^{8} - 0) \end{bmatrix} + \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \end{bmatrix} \quad (12)$$

6 Solving expression (12) for the transfer matrix gives:

$$\begin{bmatrix} (S_{TY}^{1} - 1) \\ (S_{TY}^{2} - 1) \\ (S_{TY}^{3} - 7) \\ (S_{TY}^{4} - 2) \\ (S_{TY}^{5} - 0) \\ (S_{TY}^{6} - 0) \\ (S_{TY}^{7} - 0) \\ (S_{TY}^{8} - 0) \end{bmatrix} = \begin{bmatrix} 8 \\ 6 \\ 1 \\ 7 \\ 2 \\ 1 \\ 0 \\ 0 \end{bmatrix} \quad (13)$$

$$\begin{bmatrix} 9 & 7 & 8 & 9 & 2 & 1 & 0 & 0 \end{bmatrix} \tag{14}$$

or

$$\begin{bmatrix} S_{TY}^{1} & S_{TY}^{2} & S_{TY}^{3} & S_{TY}^{4} & S_{TY}^{5} & S_{TY}^{6} & S_{TY}^{7} & S_{TY}^{8} \end{bmatrix}$$

Equation (14) is the solution for all output transfers for a particular class and in a particular "college or center" (see Figure 2 for completed flow graph). It is rather simple to put all center or college data into a computer in conjunction with this model (equation 10 or 11); this is a student flow model. University administrators could use these models quite easily to represent a student flow model for the entire institution and could interrogate the computer any time to obtain an up-to-date picture of the student flows.

## Conclusion

A student flow model has been formed from the continuity principle in order to determine student flows. Models for all centers or colleges can be held in a computer for future interrogation by interested administrators.

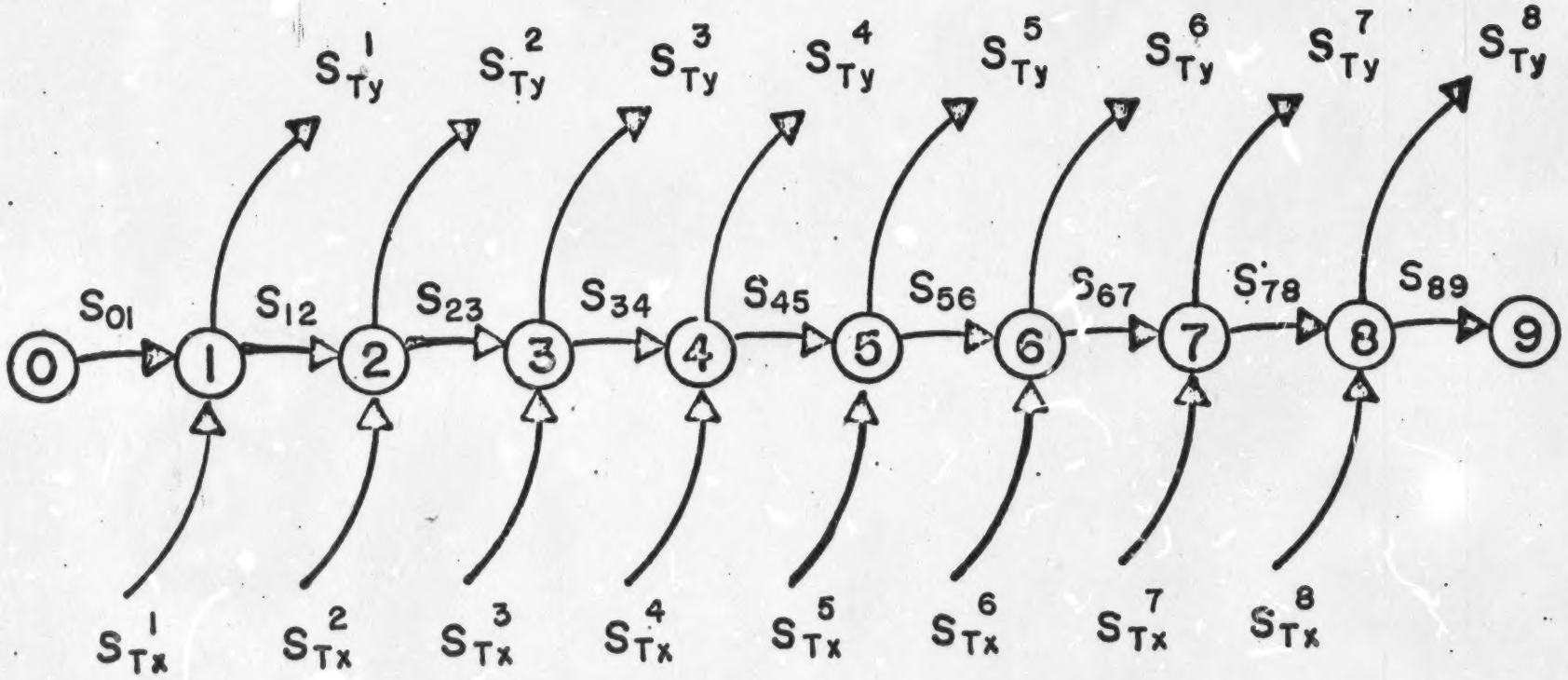
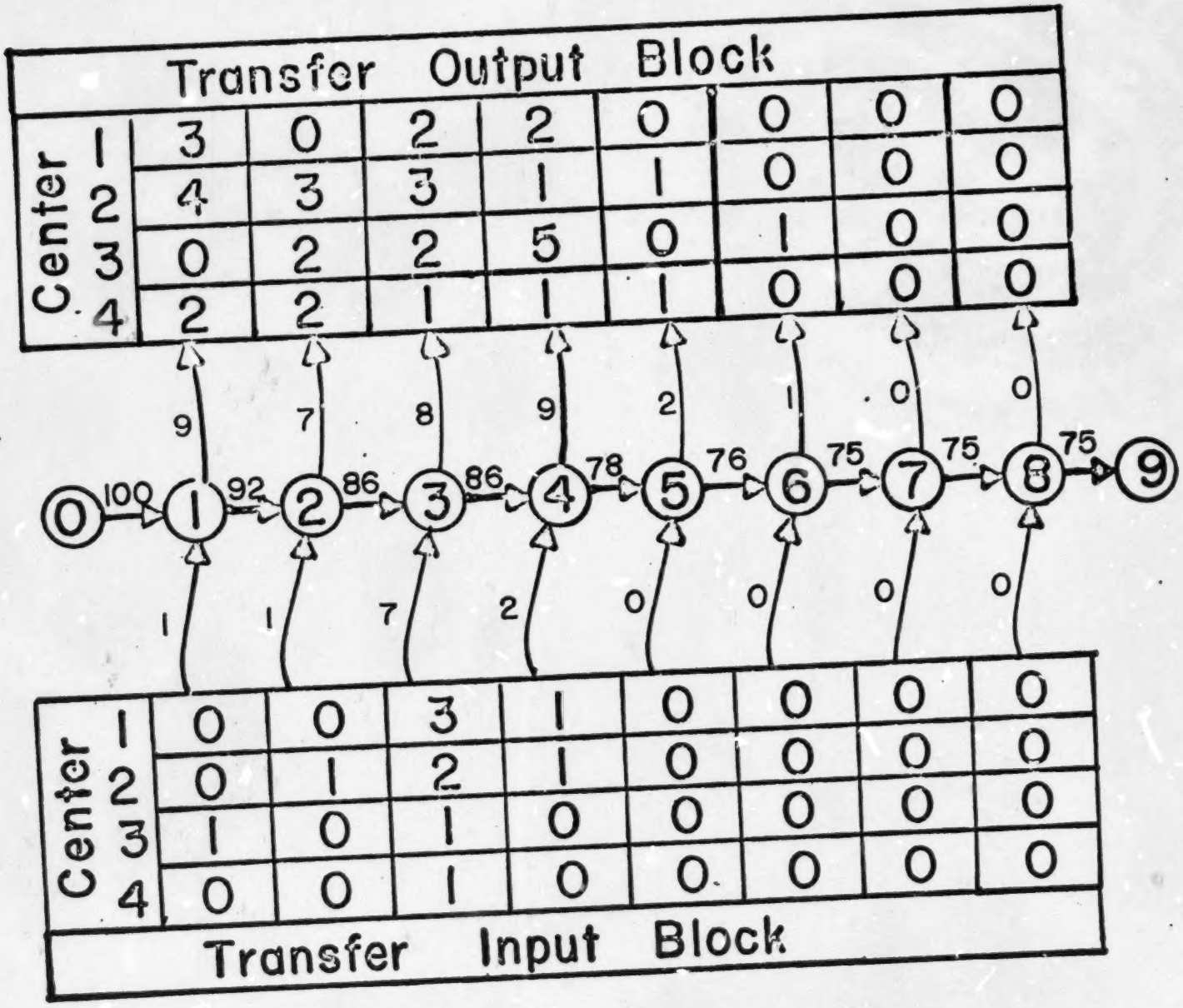



Figure 1 Student Flow System With Flows


Transfer Output Block
Center
1 3 0 2 2 0 0 0 0
2 4 3 3 1 1 0 0 0
3 0 2 2 5 0 1 0 0
4 2 2 1 1 1 0 0 0
9 7 8 9 2 1 0 0
0 100 1 92 2 86 3 86 4 78 5 76 6 75 7 75 8 75 9
1 1 7 2 0 0 0 0
Center
1 0 0 3 1 0 0 0 0
2 0 1 2 1 0 0 0 0
3 1 0 1 0 0 0 0 0
4 0 0 1 0 0 0 0 0
Transfer Input Block